IC/74/76
INTERNAL REPORT
(Limited distribution)

International Atomic Energy Agency

and

United Nations Educational Scientific and Cultural Organization

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

TOPICAL MEETING ON THE PHYSICS OF COLLIDING BEAMS

20 - 22 June 1974

(SUMMARIES AND CONTRIBUTIONS)

MIRAMARE - TRIESTE

July 1974

PHENOMENOLOGY OF VERY HIGH ENERGY HADRON INTERACTIONS

M. Jacob

CERN, Geneva, Switzerland.

ISR energy range

250 - 2000 GeV .

i) Topics related to the rising cross section

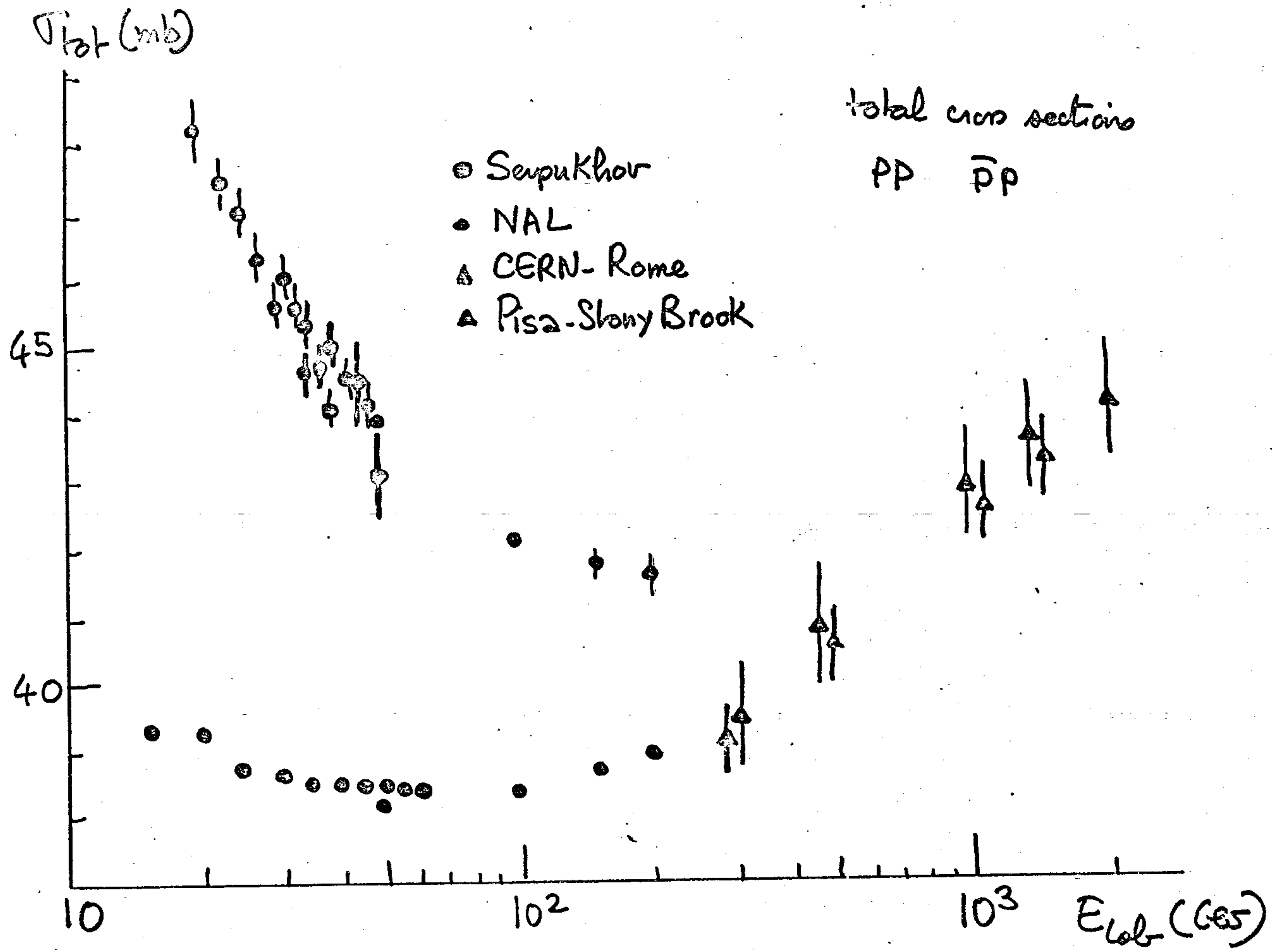
real part of the forward amplitude

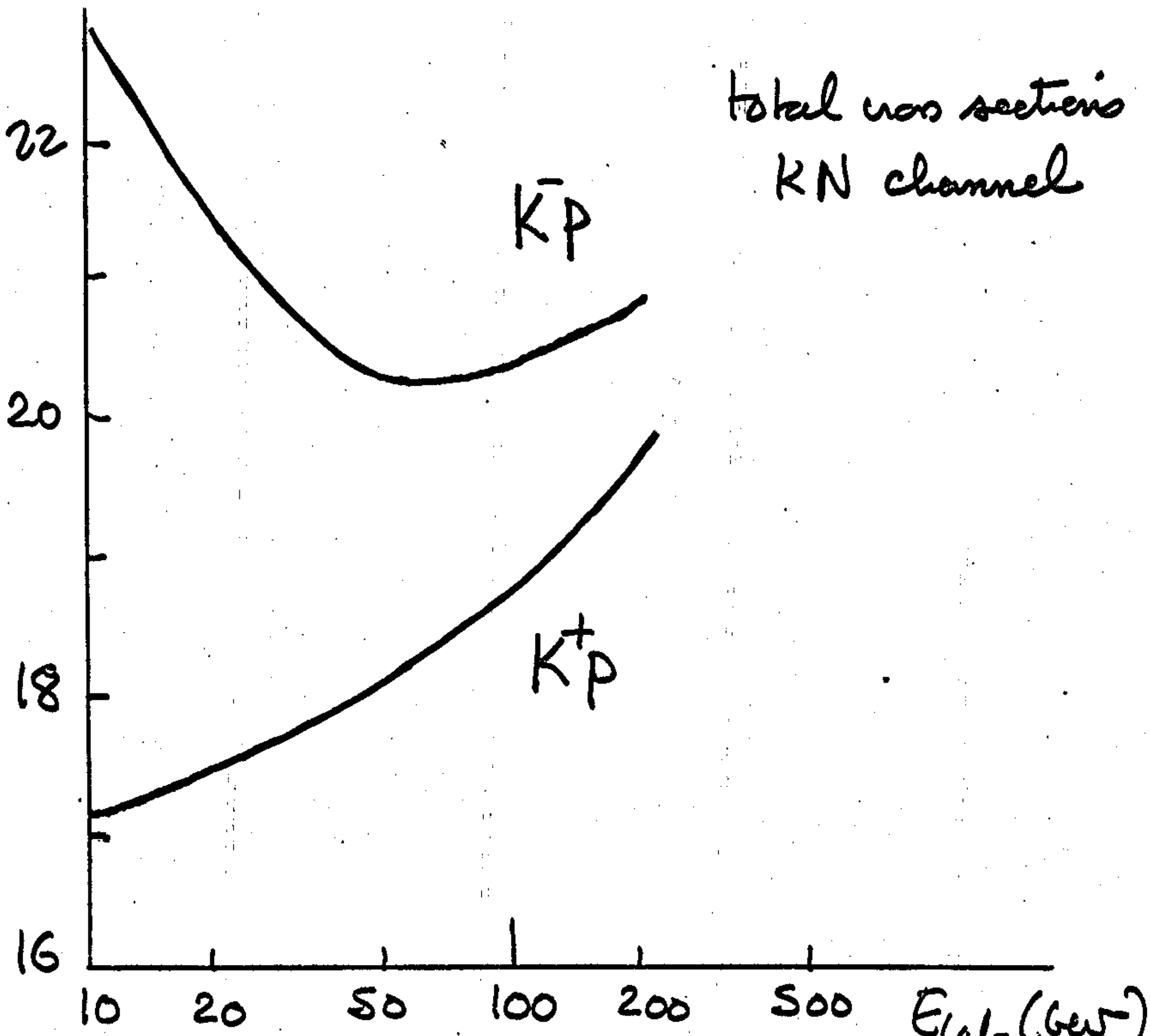
the shape of the proton

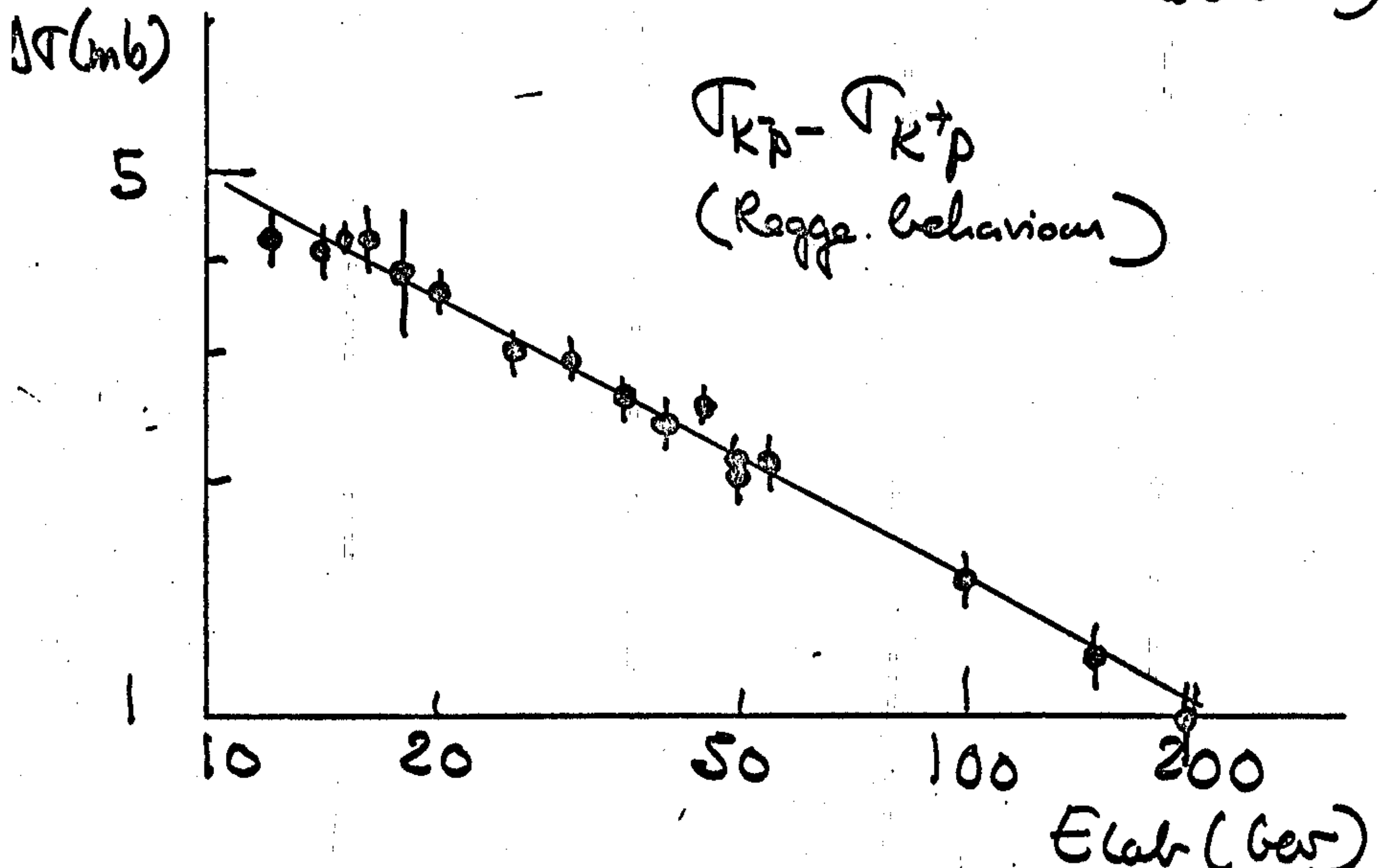
ii) Dominant configurations in many particle production

Diffractive excitation

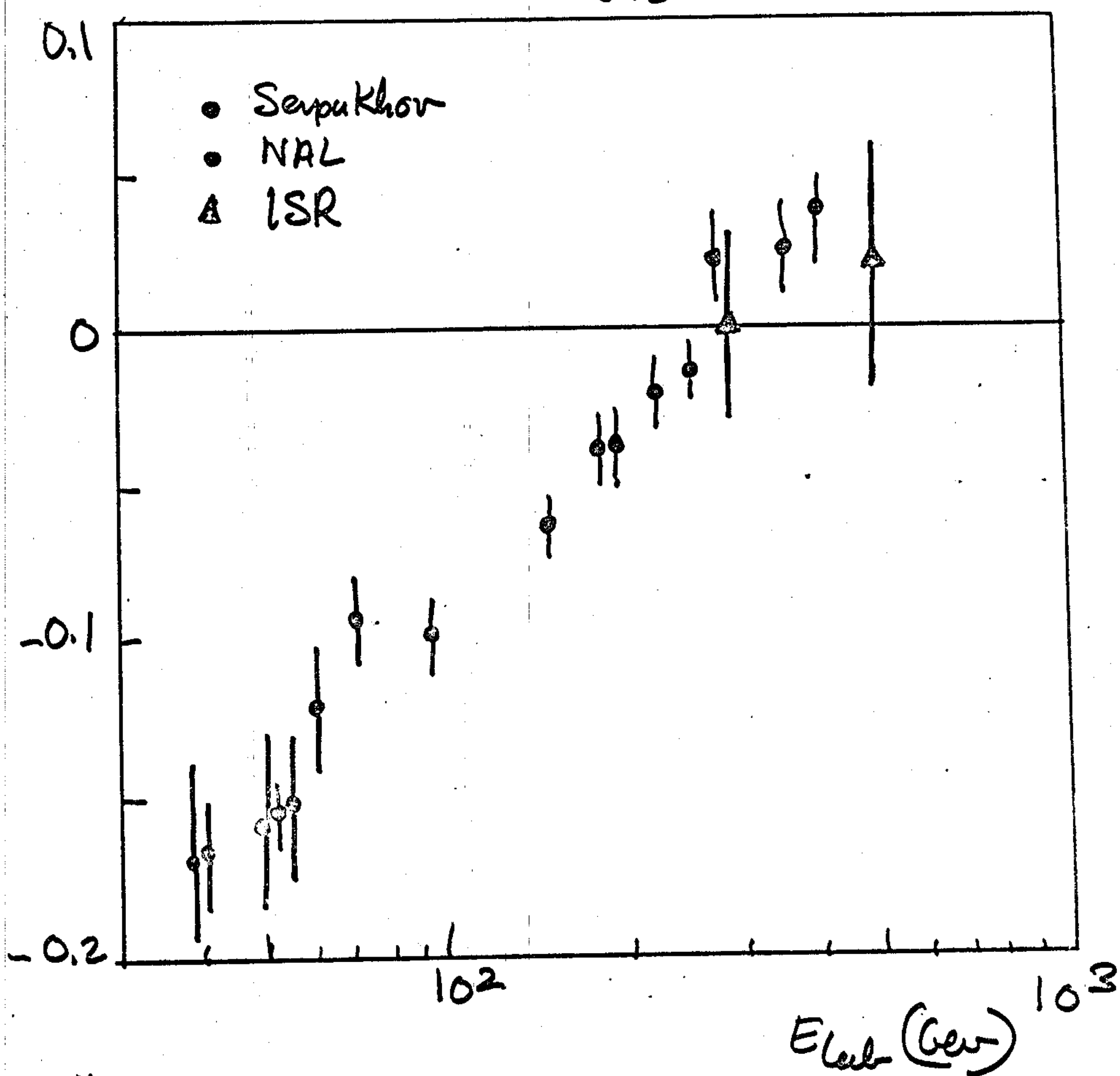
Correlations among slow CM secondaries

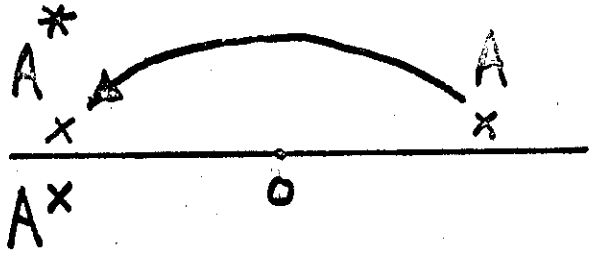

σtot (mb)
total cross sections
pp p̄p
Serpukhov
NAL
CERN-Rome
Pisa-Stony Brook
45
40
10
10²
10³
Elab (GeV)


total cross sections
KN channel
K^-p
K^+p
22
20
18
16
10
20
50
100
200
500
Elab (GeV)


Δσ (mb)
$\sigma_{K^-p} - \sigma_{K^+p}$
(Regge behaviour)
5
1
10
20
50
100
200
Elab (GeV)

$$\rho = \frac{\mathrm{Re}\, A(s,0)}{\mathrm{Im}\, A(s,0)}$$





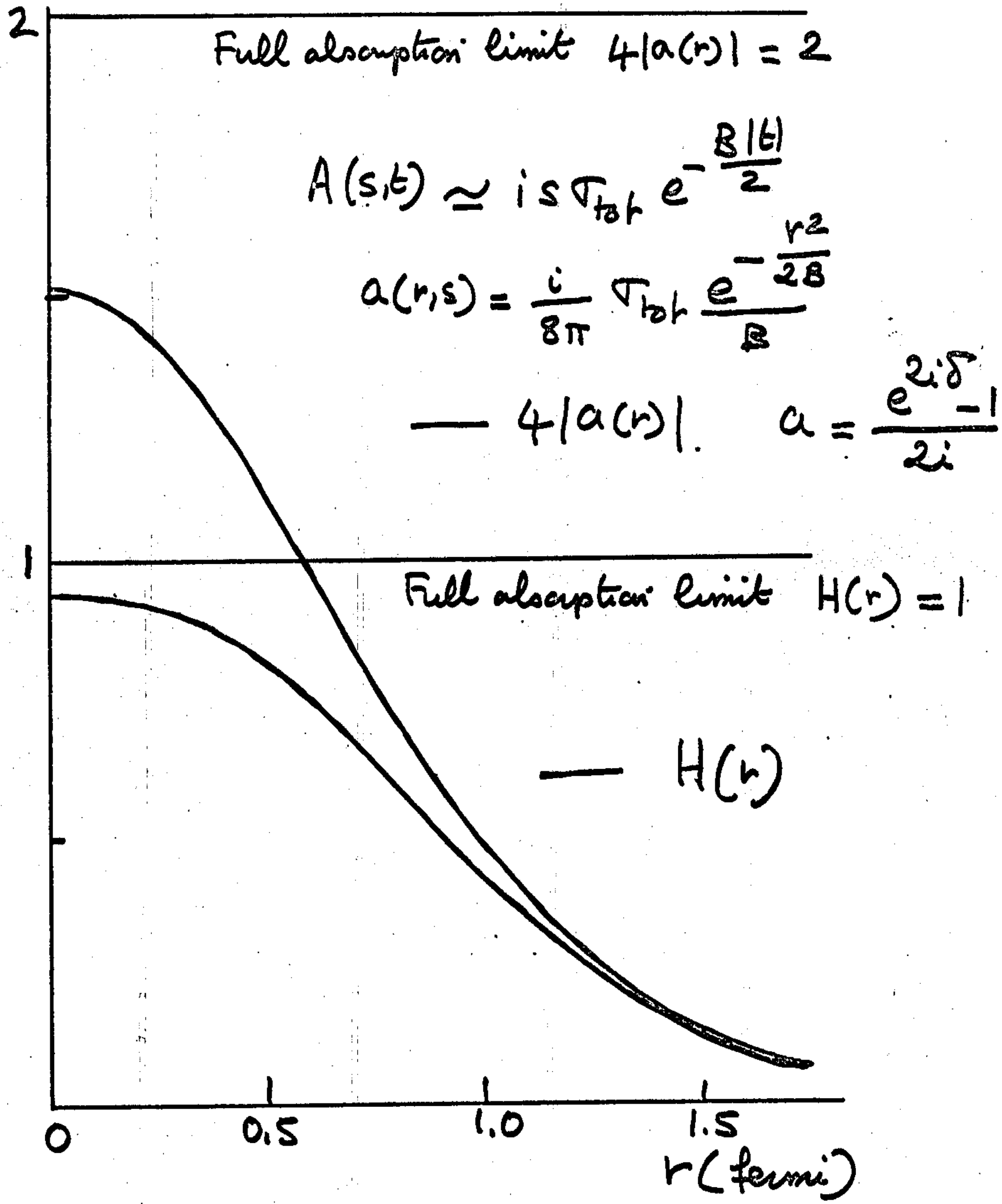
$$s \to e^{i\pi} s$$

$$\log s \to \log s + i\pi$$

$$\sigma \sim \log^\alpha s \longrightarrow A(s,0) \sim is\left(\log s - \frac{i\pi}{2}\right)^\alpha$$

$$\rho(s) \sim \frac{\alpha\pi}{2\log s} \quad \text{(positive)}$$

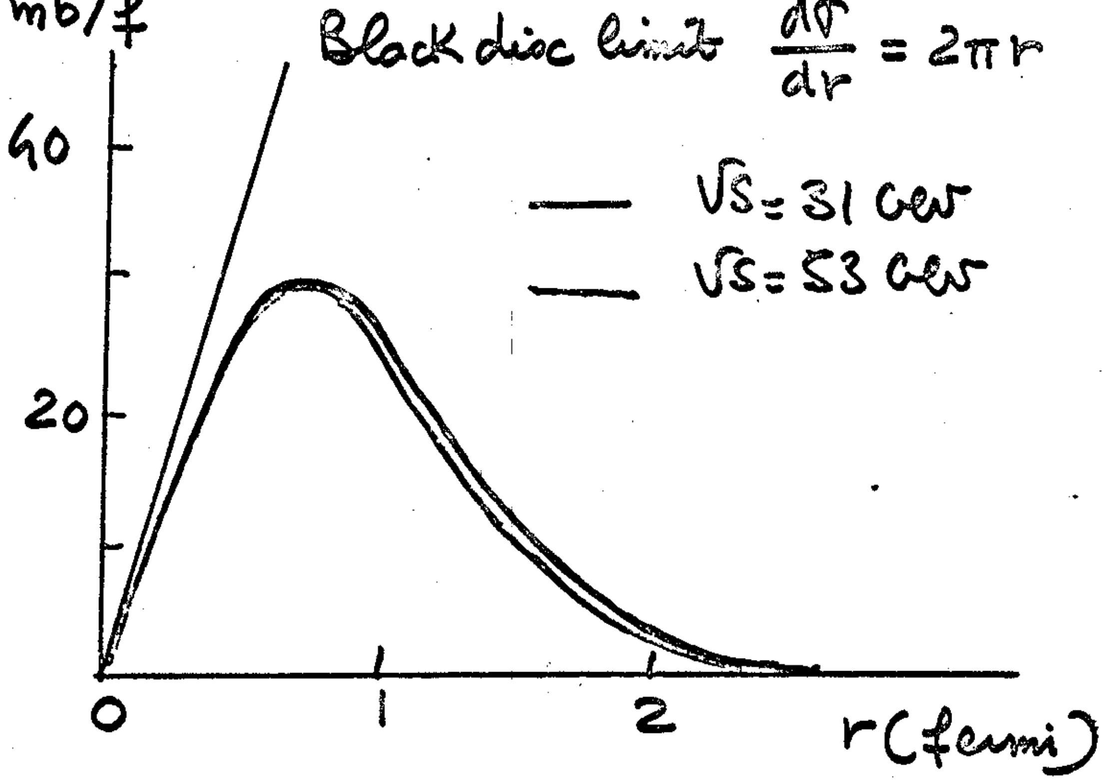
$\sqrt{s} = 53$ GeV

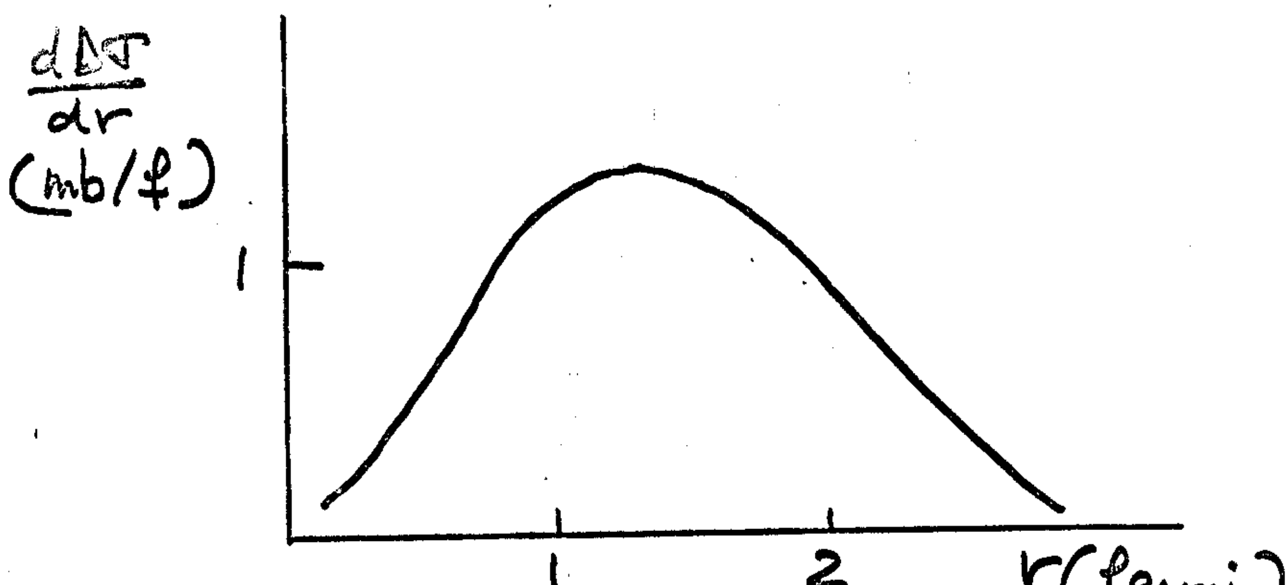


The shape of the proton

$$H(r) = \frac{1}{2\pi r} \frac{d\sigma_{in}(r)}{dr} = 4|a(r)|(1-|a(r)|)$$

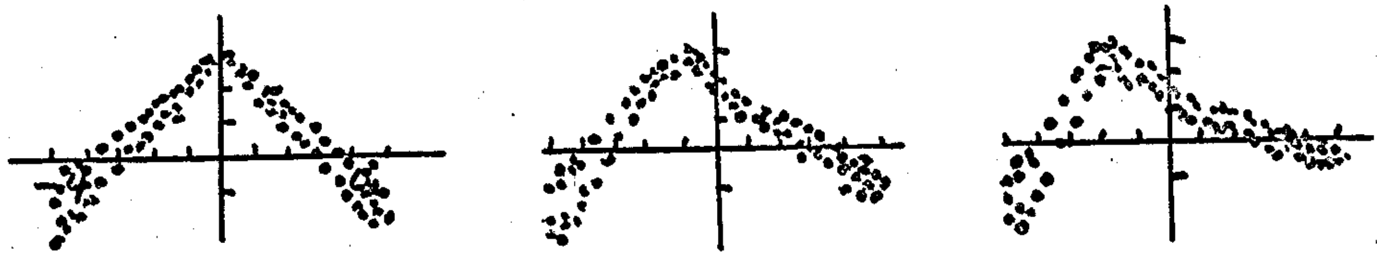
Small peripheral increase
of opacity





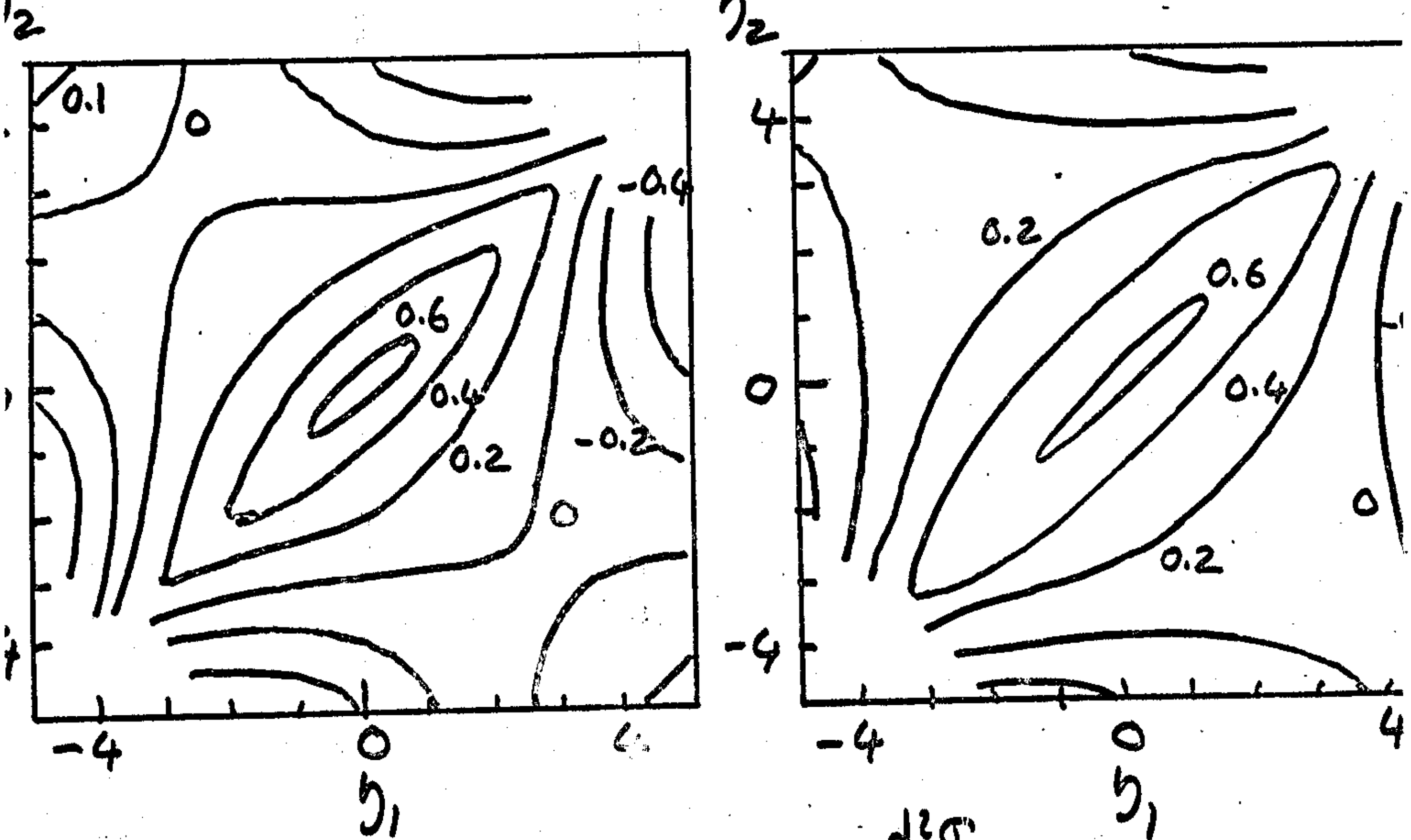
U. Amaldi
R. Henzi and P. Valin
F.S. Henyey, R.H. Tuan and G. Kane
H. Miettinen and P. Pirilä

Pisa Stony-Brook



$\eta_1 = 0$ $\qquad$ $\eta_1 = -0.87$ $\qquad$ $\eta_1 = -1.77$

$\sqrt{s} = 23$ GeV $\qquad$ $\sqrt{s} = 62$ GeV



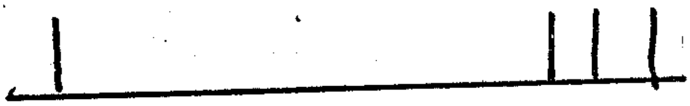
$$R(\eta_1,\eta_2) = \frac{\sigma_{in}\,\frac{d^2\sigma}{d\eta_1 d\eta_2}}{\frac{d\sigma}{d\eta_1}\,\frac{d\sigma}{d\eta_2}} - 1$$

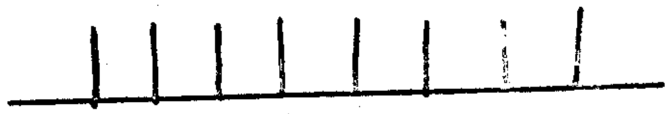
$$\eta = -\mathrm{Log}\; tg\,\frac{\theta}{2} \sim y$$

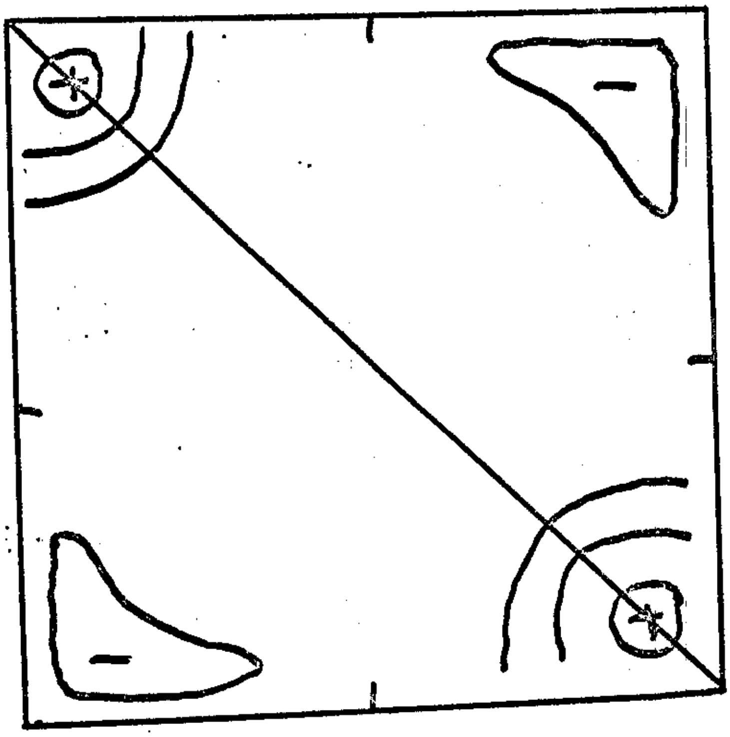
$r(0,0) =$ 0.65 ± 0.06 charged-charged (ISR

$\qquad\quad$ 0.65 ± 0.08 charged-neutral (ISR.

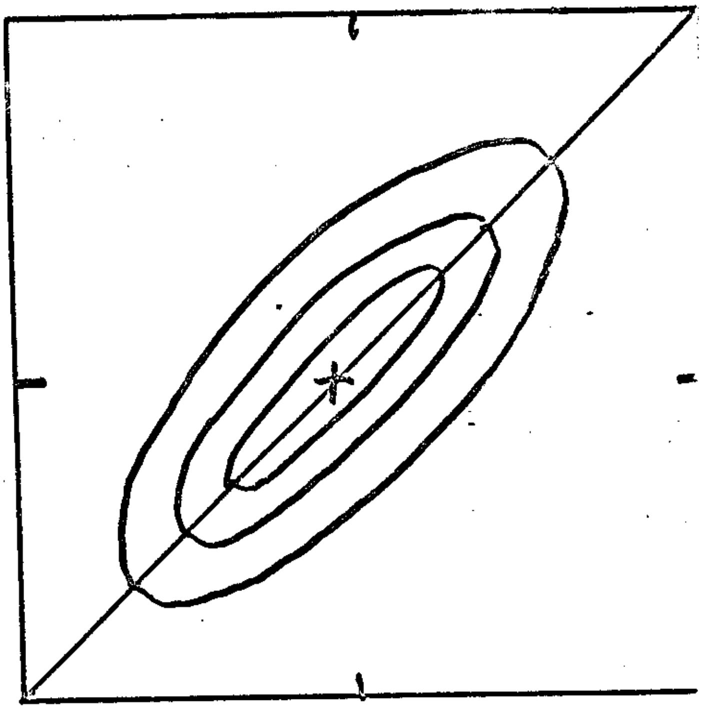
Two main Components







Diffractive
Imposes long range effects



Non Diffractive
Could be mainly short range in nature

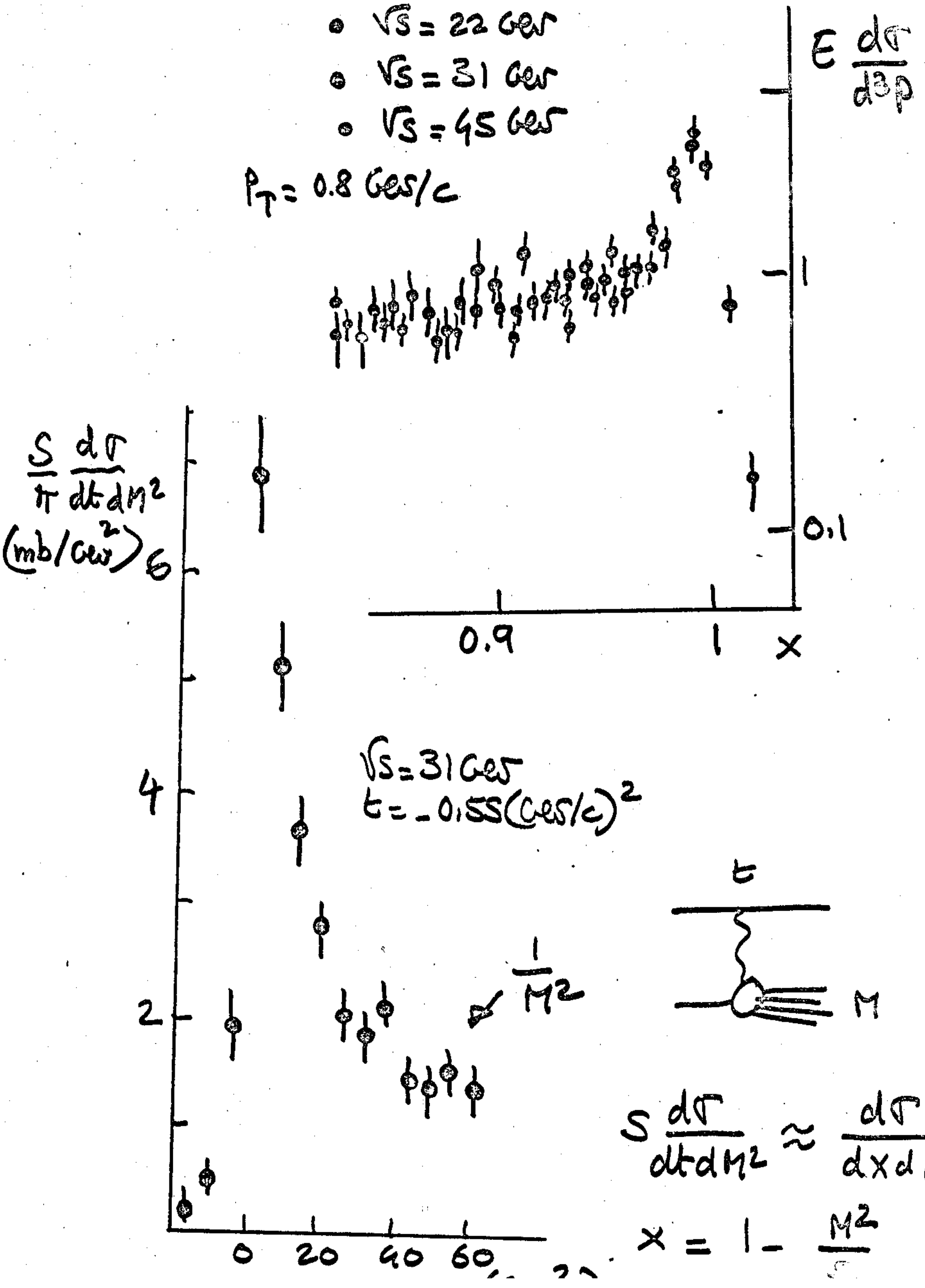
$$\sigma_D = \alpha \sigma \qquad \sigma_{ND} = (1-\alpha)\sigma$$

$$C(y_1, y_2) = \alpha C_D(y_1, y_2) + (1-\alpha) C_{ND}(y_1, y_2)$$

$$+ \alpha(1-\alpha)\left(\rho_{ND}(y_1) - \rho_D(y_1)\right)\left(\rho_{ND}(y_2) - \rho_D(y_2)\right)$$

$$C(0,0) \approx (1-\alpha) C_{ND}(0,0) + \alpha(1-\alpha)\, \rho_{ND}^2(0)$$

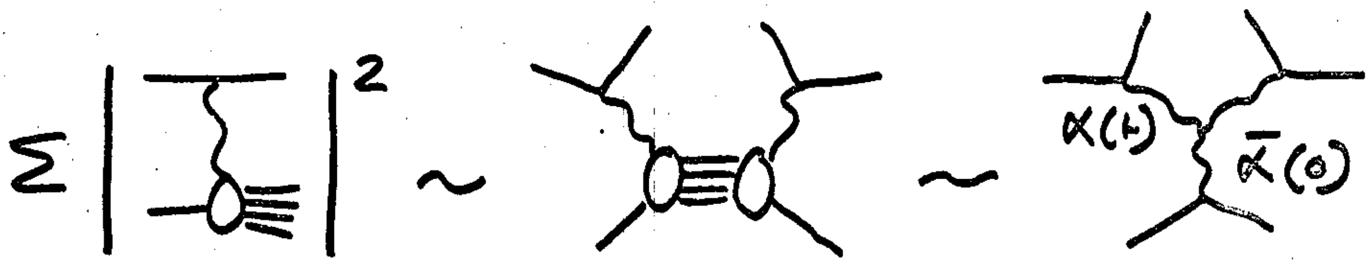
Single Diffractive excitation
CERN-Holland-Lancaster-Manchester



$$s\frac{d\sigma}{dt\,dM^2} \approx \frac{d\sigma}{dx\,dp_T^2}$$

$$x = 1 - \frac{M^2}{s}$$

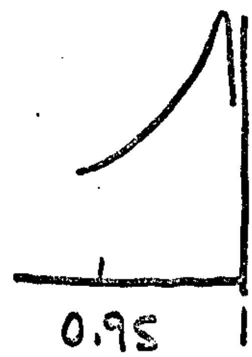
Triple Regge Formalism



$$x\frac{d\sigma}{dx\,dp_T^2} \sim \frac{R(t)}{s}\left(\frac{s}{M^2}\right)^{2\alpha(t)}\left(M^2\right)^{\bar{\alpha}(0)}$$

If $\alpha(t) \sim 1$

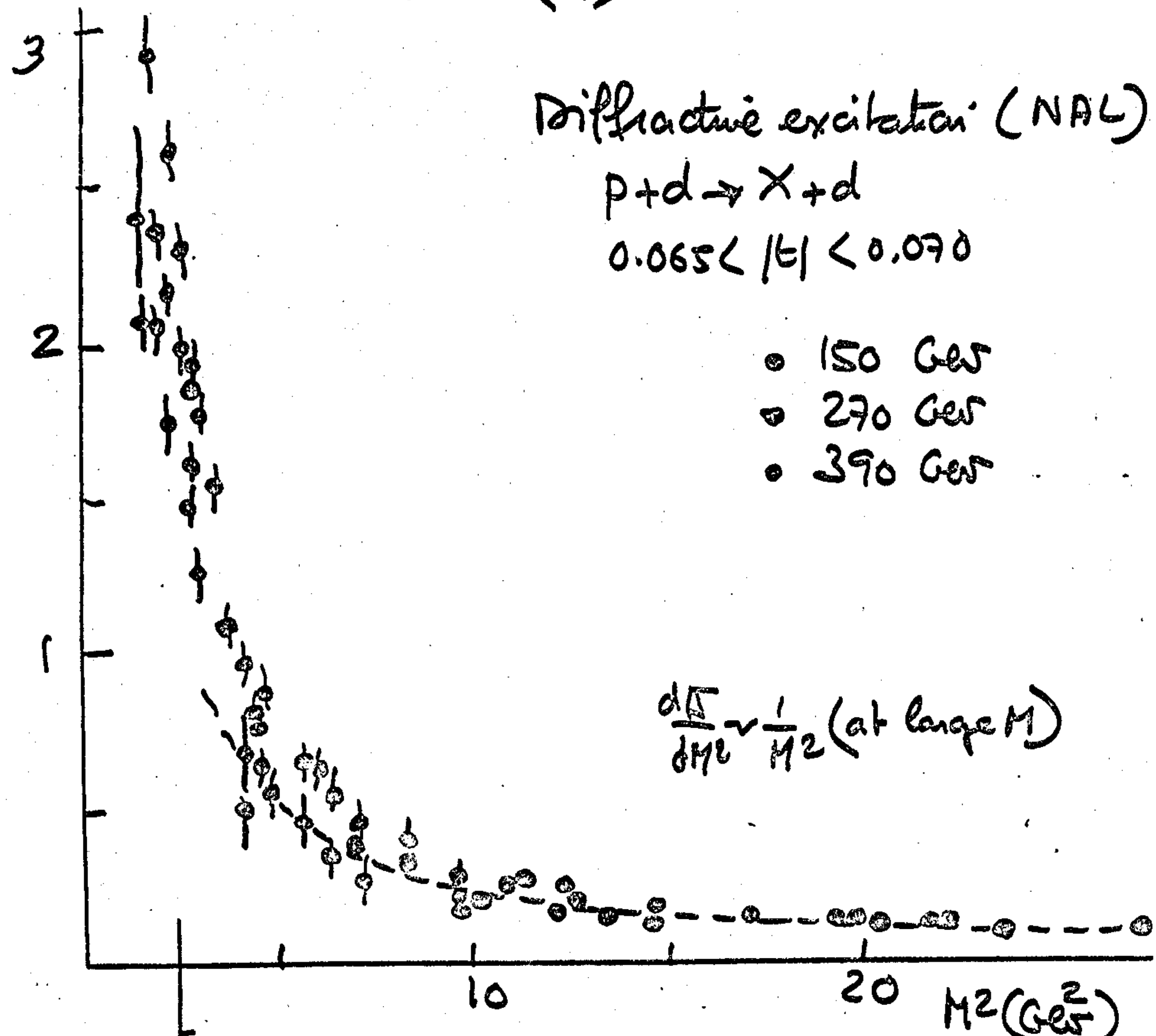
$x\frac{d\sigma}{dx}$	$\frac{d\sigma}{dM^2}$	$\bar{\alpha}(0)$
$\frac{1}{1-x}$	$\frac{1}{M^2}$	1
$\frac{1}{\sqrt{s}}\,\frac{1}{(1-x)^{3/2}}$	$\frac{1}{M^3}$	$\frac{1}{2}$

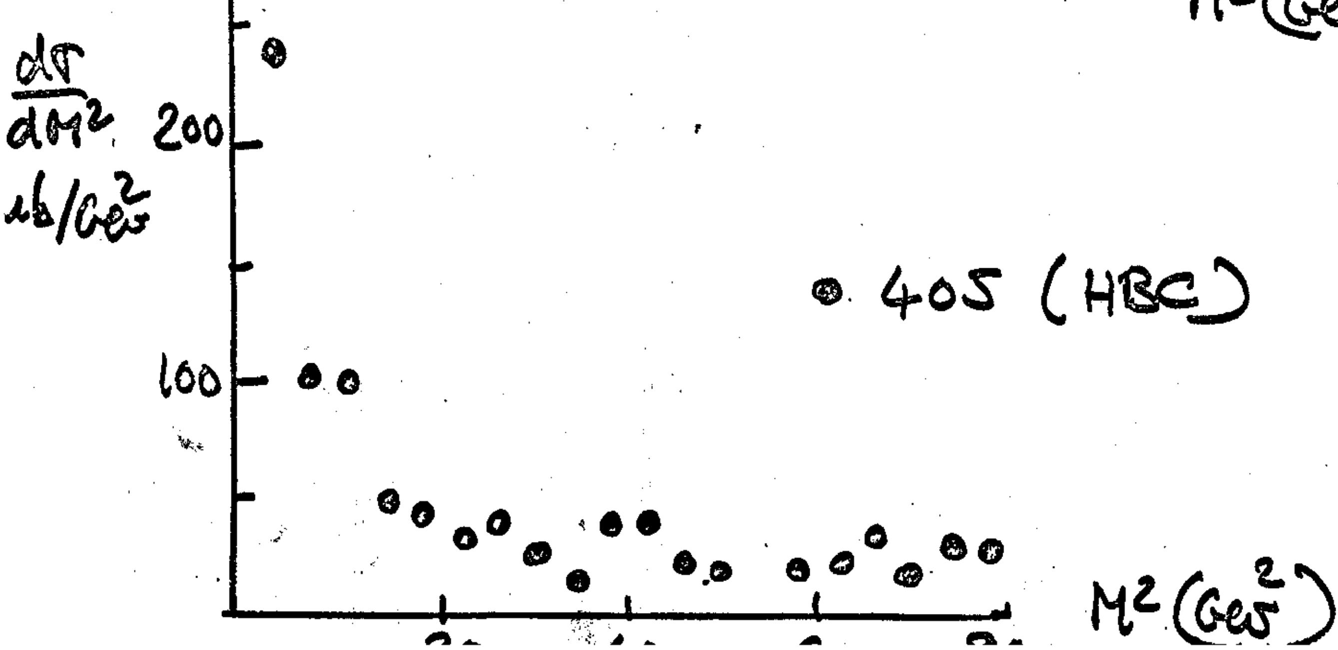


Scaling ~ Triple Regge contribution

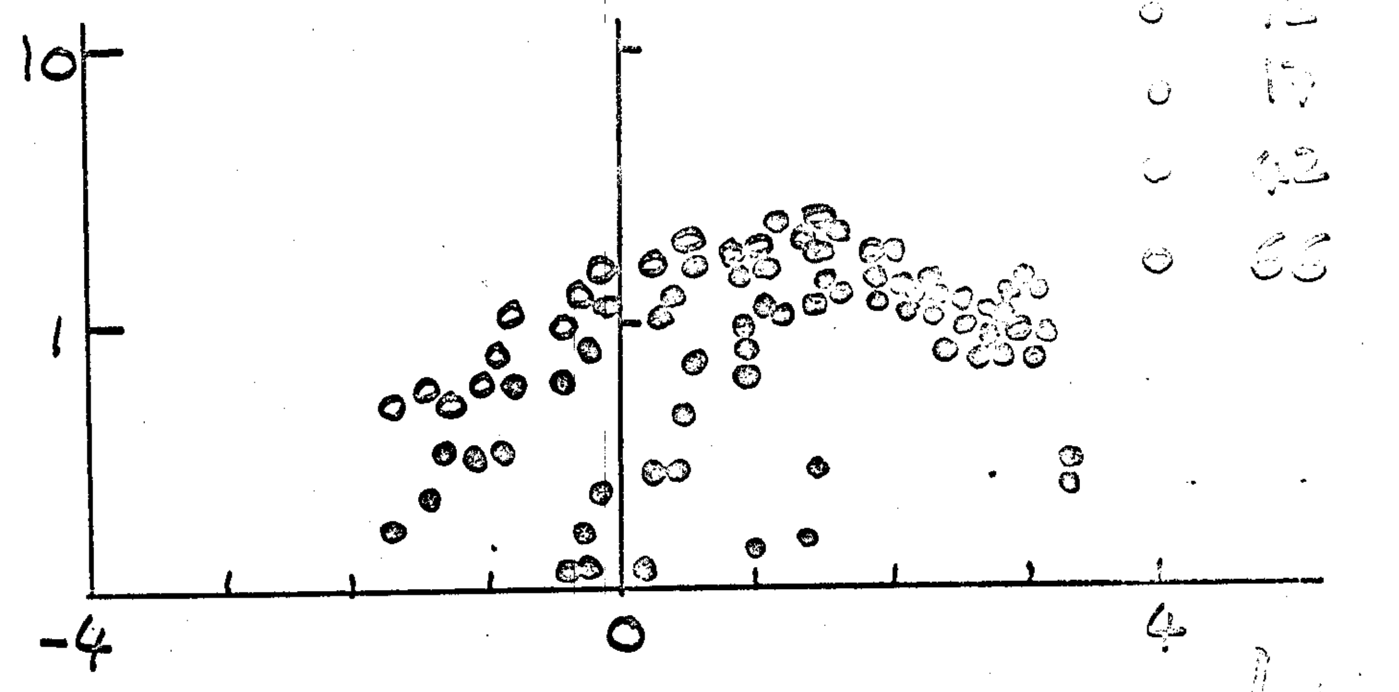
s independence of $\frac{d\sigma}{dM^2}$ (diffraction) ~ $x\frac{d\sigma}{dx}$ rises at $x \simeq 1$

$$\frac{d\sigma}{dM^2} \sim \left(\frac{s}{M^2}\right)^{2(\alpha(t)-1)} \left(M^2\right)^{\bar{\alpha}(0)-2}$$





Rapidity Distribution

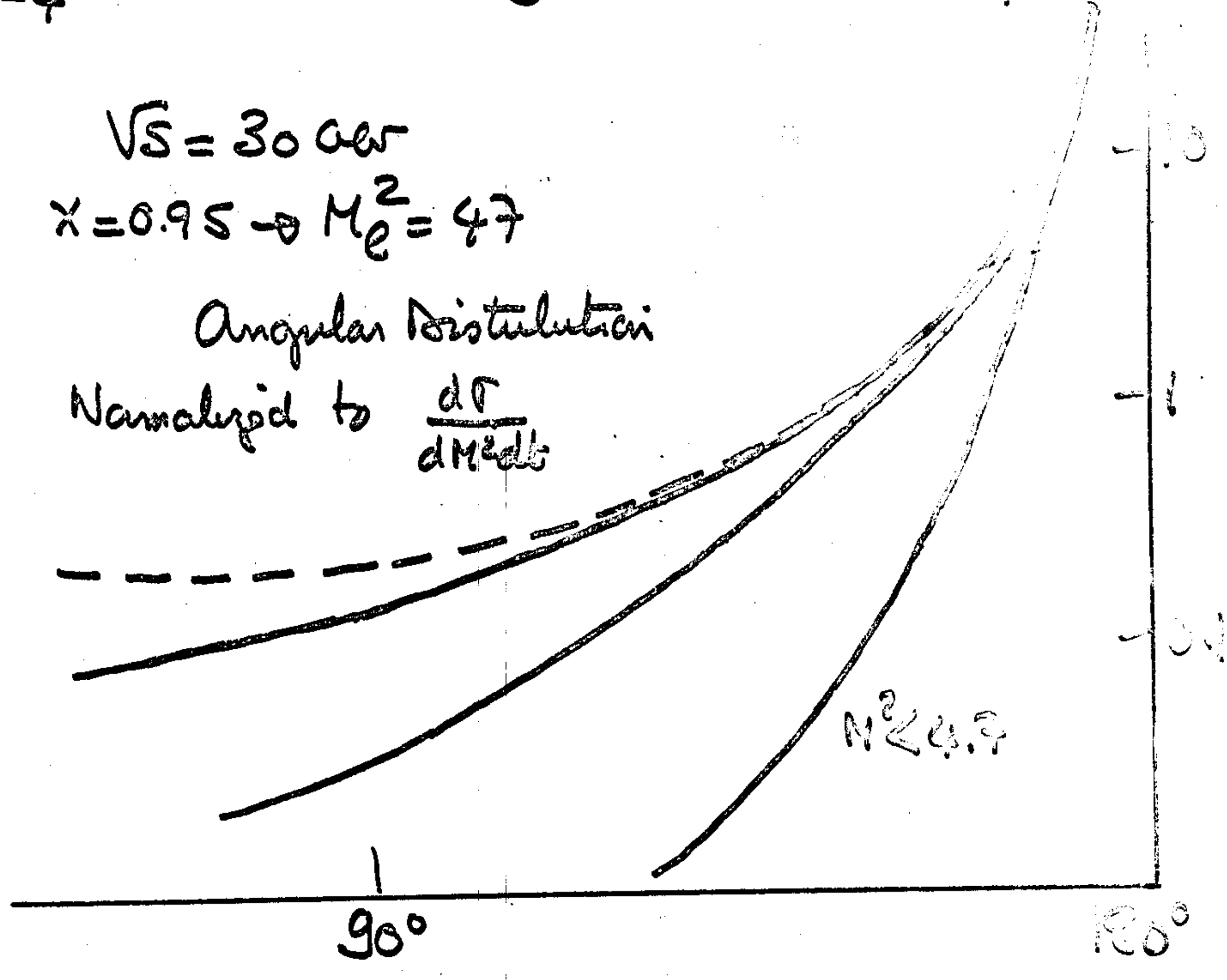


$\sqrt{s} = 30$ GeV

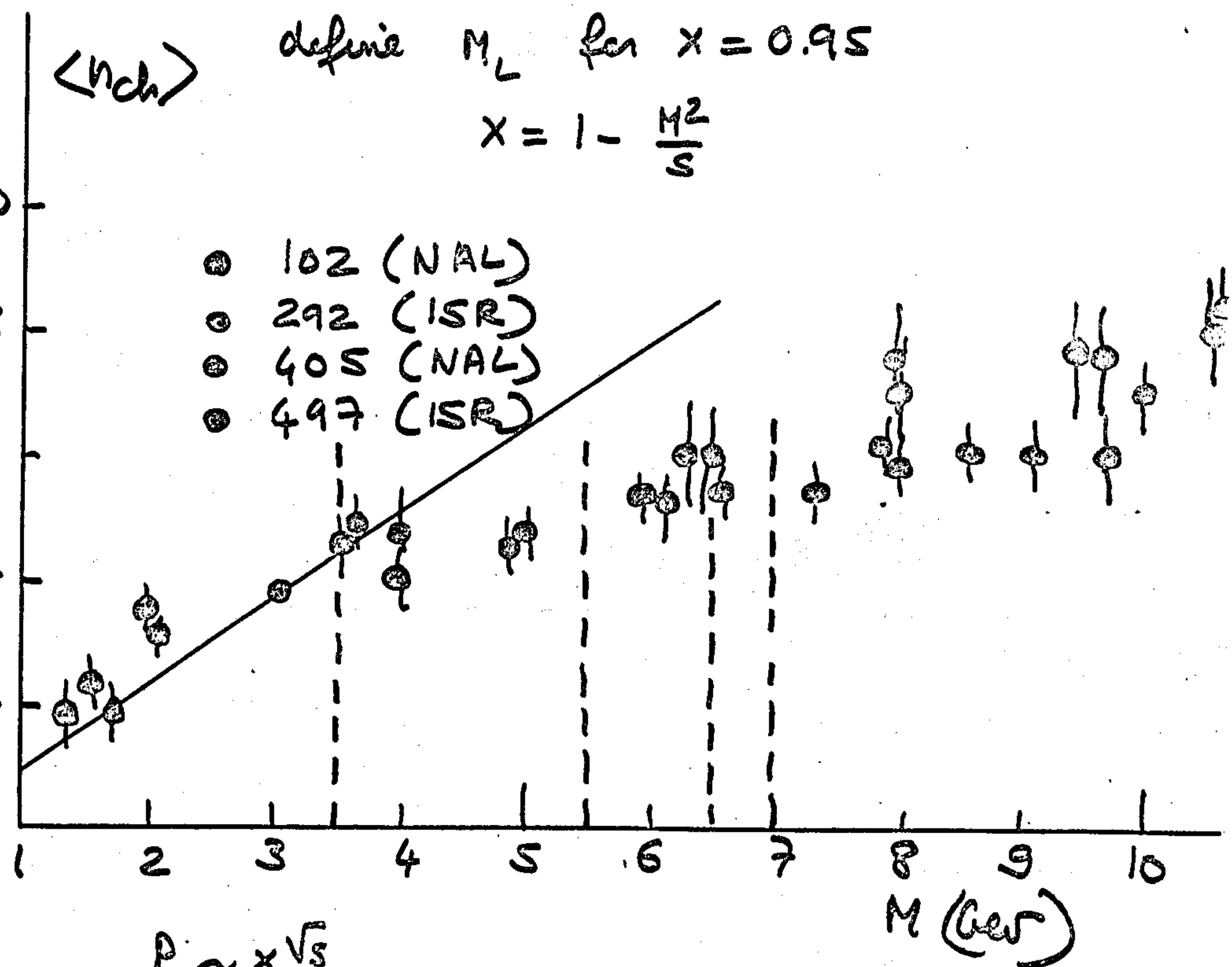
$x = 0.95 \rightarrow M_\ell^2 = 47$

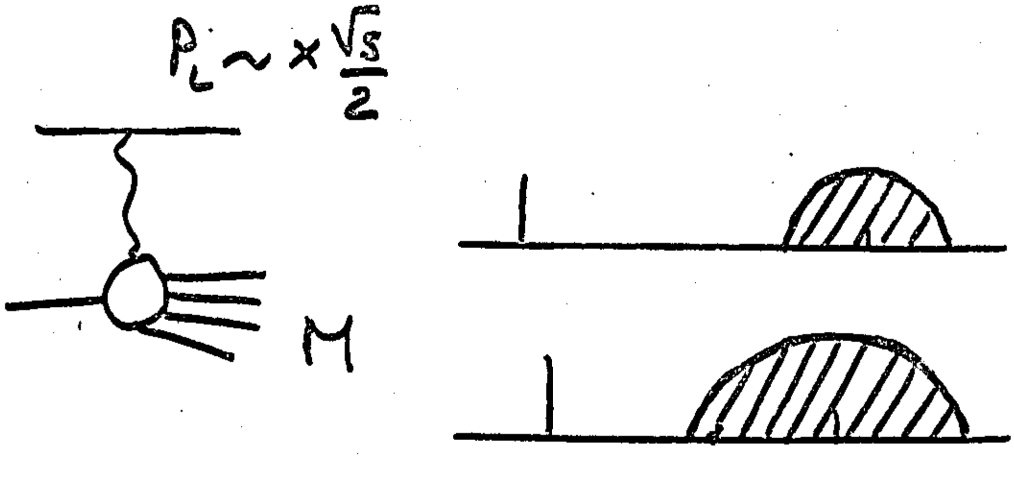
Angular Distribution

Normalized to $\frac{d\sigma}{dM^2 dt}$



Associated charged multiplicity



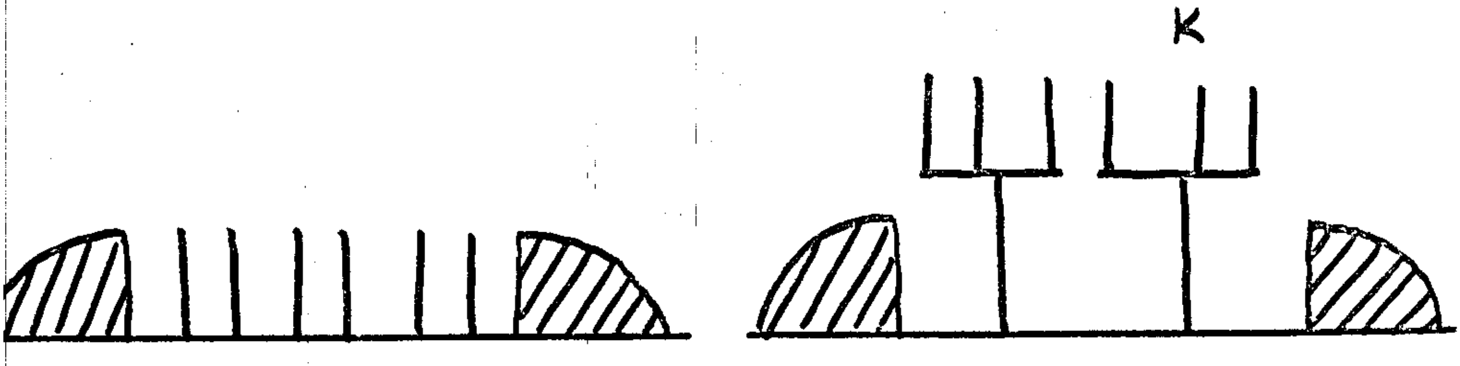


$\bar{y} = \log \frac{\sqrt{s}}{M}$

leading proton effect → Double P exchange

similarity with photoproduction (?)

The cluster picture



Central region

$$R(y_1, y_2) = \frac{C(y_1, y_2)}{\rho(y_1)\,\rho(y_2)}$$

$$R(\Delta y) \approx \frac{C_{ND}(\Delta y)}{(1-\alpha)(\rho_{ND})^2} + \frac{\alpha}{1-\alpha}$$

Cluster $\quad \rho_c = \frac{\rho_{ND}}{\langle K \rangle}$

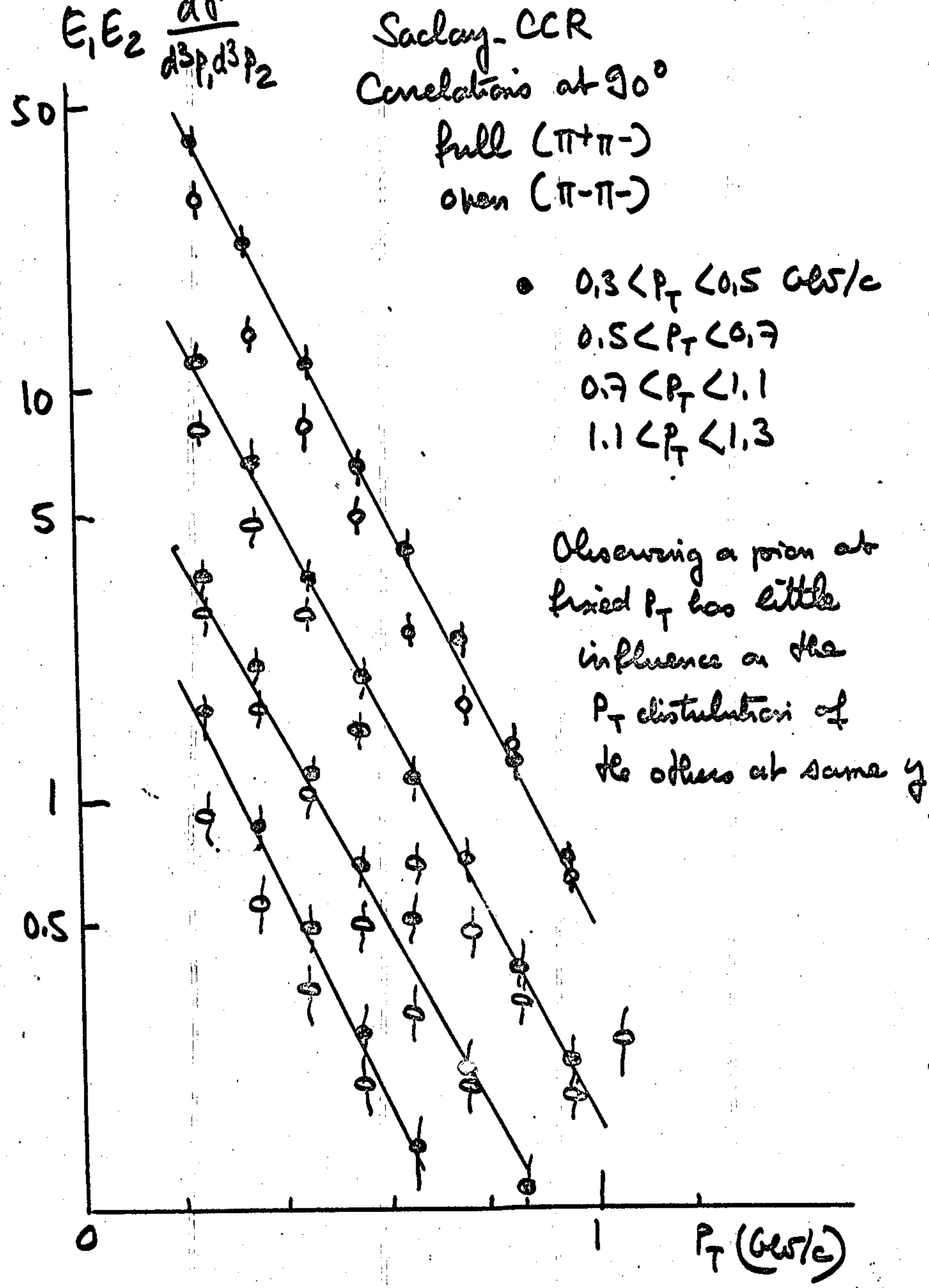
$$R_{ND}(\Delta y) \approx \frac{\rho_c\, D(\Delta y)\, \langle K(K-1)\rangle}{\rho_c^2 \langle K \rangle^2}$$

$$\approx \frac{D(\Delta y)}{\rho_{ND}} \frac{\langle K(K-1)\rangle}{\langle K \rangle}$$

$\langle K \rangle \sim 3$ charged particles

4 - 5 pions (neutral clusters)

$\langle M_c \rangle \sim 2$ GeV


$E_1E_2 \frac{d\sigma}{d^3p_1 d^3p_2}$
Saclay-CCR
Correlations at 90°
full (π+π-)
open (π-π-)
0.3 < P_T < 0.5 GeV/c
0.5 < P_T < 0.7
0.7 < P_T < 1.1
1.1 < P_T < 1.3
Observing a pion at fixed P_T has little influence on the P_T distribution of the others at same y
50
10
5
1
0.5
0
1
P_T (GeV/c)

Tests of the cluster picture

i) Energy independence

ii) Cluster parameters for fixed n

$$C^{(n)}(y_1, y_2) = \alpha_n C_D^{(n)}(y_1, y_2) + (1-\alpha_n) C_{ND}^{(n)}(y_1, y_2) + \alpha_n(1-\alpha_n) D^{(n)}(y_1) D^{(n)}(y_2)$$

n large enough $\alpha_n = 0$

$$C^{(n)}(y_1, y_2) \approx C_{ND}^{(n)}(y_1, y_2)$$

$$C^{(n)}(y_1, y_2) = \frac{n}{\log s} \frac{\langle K(K-1)\rangle_n}{\langle K\rangle_n} D(y_1 - y_2) + \cdots$$

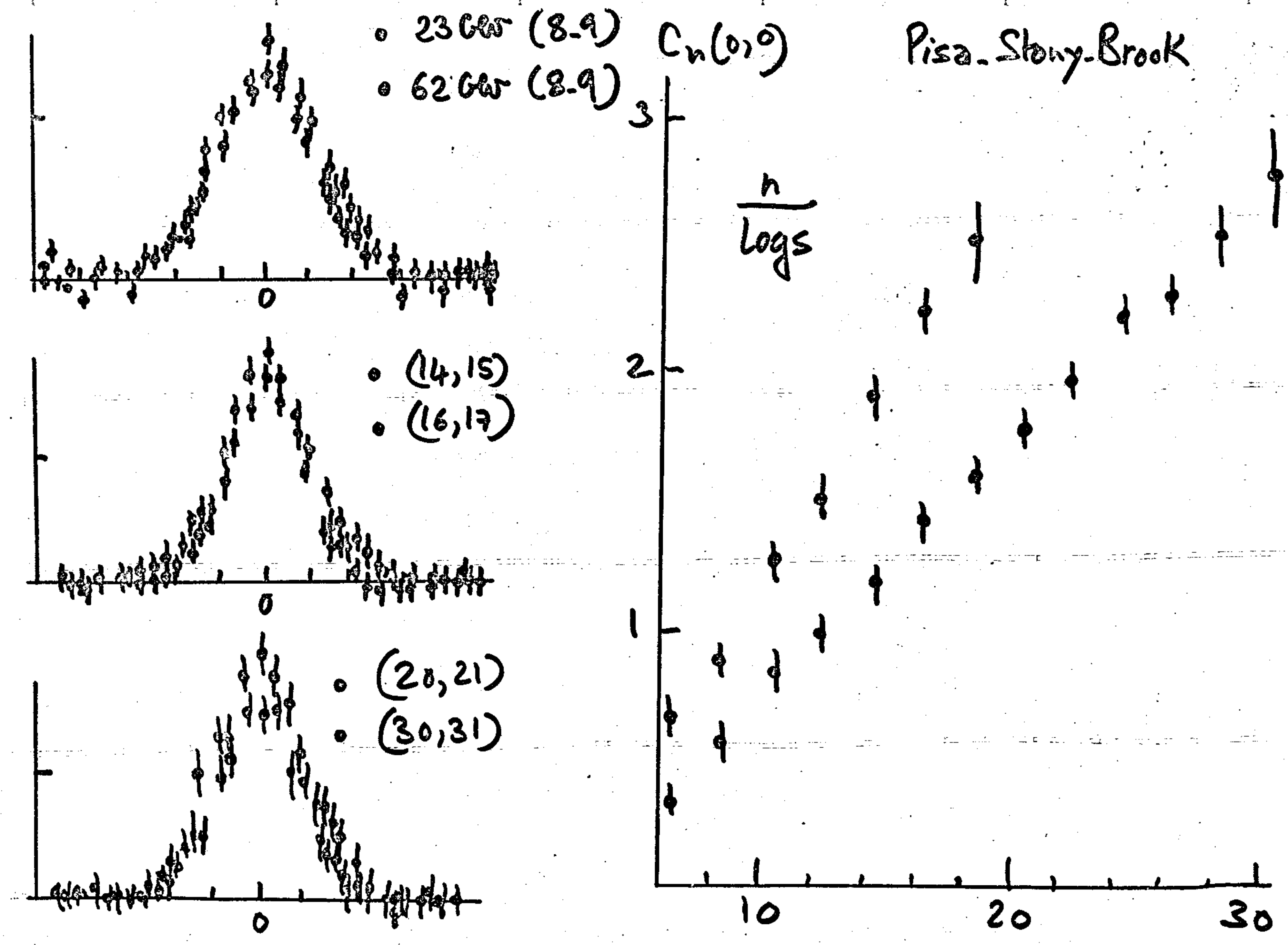
Independent clusters

$$G(z) = e^{\langle N\rangle (g(z)-1)}$$

$$D(y_1 - y_2) = \frac{1}{2\sqrt{\pi}\delta} \exp\left(-\frac{(y_1-y_2)^2}{4\delta^2}\right)$$

$$R(\Delta y) = \frac{\log s}{n} D(\Delta y) \frac{\langle K(K-1)\rangle_n}{\langle K\rangle_n}$$

iii) Clustering effects associated with heavy particles


Pisa-Stony-Brook
$C_n(0,0)$
23 GeV (8-9)
62 GeV (8-9)
(14,15)
(16,17)
(20,21)
(30,31)
$\frac{n}{\log s}$
0
0
0
1
2
3
10
20
30

Correlations at wide angle
Saclay - CCR
ISR $\sqrt{s} = 53$ GeV
(uncorrected ratios)

Ratio (2) \ Seen (1)	π^+	π^-	p	$\bar{p}$
p/π^+	0.053 $\pm$ 0.005	0.051 $\pm$ 0.004	0.12 $\pm$ 0.022	0.073 $\pm$ 0.021
p/π^-	0.045 $\pm$ 0.004	0.067 $\pm$ 0.006	0.10 $\pm$ 0.020	0.092 $\pm$ 0.027
$\bar{p}/\pi^+$	0.029 $\pm$ 0.005		0.065 $\pm$ 0.016	
$\bar{p}/\pi^-$	0.024 $\pm$ 0.003		0.055 $\pm$ 0.014	

Inclusive $p/\pi^+ = 0.056 \pm 0.005$

$\bar{p}/\pi^- = 0.026 \pm 0.003$

$$R_{p\pi} \sim R_{\pi\pi}$$